I. AMENDMENTS TO THE CLAIMS:

Kindly amend claims 1, 4, 7, 9, 11, 14 and 15 as follows.

The following Listing of Claims replaces all prior listing, or versions, of claims in the above-captioned application.

Listing of Claims:

1. (Currently Amended) A method for numerical analysis of a flow field of incompressible viscous fluid, directly using V-CAD data, comprising the steps of:

(A) dividing external data into a plurality of cells having boundaries orthogonal to each other, the external data including boundary data of an object that contacts incompressible viscous fluid;

(B) classifying the divided cells into an internal cell positioned inside or outside the object and a boundary cell including the boundary data;

(C) determining cut points in ridges of the boundary cell on the basis of the boundary data;

(D) determining a polygon connecting the cut points to be cell internal data for the boundary face; ~~and~~

(E) applying a cut cell finite volume method combined with a VOF method to a boundary of a flow field to analyze the flow field, wherein step (E) comprises the steps of

i. applying a two-dimensional QUICK interpolation scheme to a convection term for space integral;

ii. applying a central difference having precision of a degree of a second order to a diffusion term;

iii. combining the convection term and the diffusion term, and applying an Adams-Bashforth method having precision of a degree of a second order to the

combined convection term and diffusion term for time marching; and

iv. applying a Euler implicit method having precision of a degree of a first order to a pressure gradient term for time marching,

wherein for a two-dimensional boundary cell, a governing equation in the finite volume method is expressed by a governing equation (7),

$$\iint_{V_{i,j}} \frac{\partial \vec{u}}{\partial t} dV = -\iint_{V_{i,j}} div(\vec{u} \otimes \vec{u}) dV - \iint_{V_{i,j}} div(p\vec{I}) dV + \frac{1}{\mathrm{Re}} \iint_{V_{i,j}} div(grad(\vec{u})) dV \qquad (7)$$

,

wherein $-\iint_{V_{i,j}} div(\vec{u} \otimes \vec{u}) dV$ corresponds to the convection~~convention~~ term,

$-\iint_{V_{i,j}} div(p\vec{I}) dV$ corresponds to the pressure gradient term, and

$+\frac{1}{\mathrm{Re}} \iint_{V_{i,j}} div(grad(\vec{u})) dV$ corresponds to the diffusion term, wherein $\vec{u}$ designates velocity of flow of viscous fluid, V designates differential volume of the viscous fluid, $p\vec{I}$ designates pressure p of the viscous fluid along the $\vec{I}$ vector, and Re corresponds to a non-dimensional Reynolds number; and

(F) outputting to an output device a result of the method for numerical analysis of the flow field of incompressible viscous fluid, wherein the output device prints, or displays, or prints and displays, the result.

2. (Cancelled)
3. (Cancelled)

4. (Currently Amended) A method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 1, wherein the convection term, the pressure gradient term and the diffusion term in the governing equation of the finite volume method are expressed by the equations (8), (9) and (10), respectively,

convection term:

$$\begin{aligned}&\iint_{V_{i,j}} div(\vec{u}\otimes\vec{u})dV = \oint\!\!\!\oint_{S_{1-5}} (\vec{u}\otimes\vec{u})\cdot\vec{n}dS = \sum_{m=1-5}(\vec{u}\otimes\vec{u})_m\cdot\vec{n}\delta S_m\\
&=[\Delta y(B_{i,j}u^{(x)}_{i,j}u_{i,j} - B_{i-1,j}u^{(x)}_{i-1,j}u_{i-1,j})\\
&+\Delta x(A_{i,j}u^{(y)}_{i-1/2,j+1/2}v_{i,j} - A_{i,j-1}u^{(y)}_{i-1/2,j-1/2}v_{i,j-1})]\vec{i}\\
&+[\Delta y(B_{i,j}v^{(x)}_{i+1/2,j-1/2}u_{i,j} - B_{i-1,j}v^{(x)}_{i-1/2,j-1/2}u_{i-1,j})\\
&+\Delta x(A_{i,j}v^{(y)}_{i,j}v_{i,j} - A_{i,j-1}v^{(y)}_{i,j-1}v_{i,j-1})]\vec{j}\,|only\,no-slip\quad on\,wall\end{aligned}\tag{8}$$

pressure gradient term:

$$\begin{aligned}&\iint_{V_{i,j}} div(p\vec{I})dV = \oint\!\!\!\oint_{S_{1-5}} (p\vec{I})\cdot\vec{n}dS = \sum_{m=1-5} p_m\vec{I}\cdot\vec{n}\delta S_m\\
&=\Delta y[B_{i,j}p_{i+1/2,j} - B_{i-1,j}p_{i-1/2,j} - p_p(B_{i,j}-B_{i-1,j})]\vec{i}\\
&+\Delta x[A_{i,j}p_{i,j+1/2} - A_{i,j-1}p_{i,j-1/2} - p_p(A_{i,j}-A_{i,j-1})]\vec{j}\end{aligned}\tag{9}$$

diffusion term:

$$\begin{aligned}&\iint_{V_{i,j}} div(grad(\vec{u}))dV = \oint\!\!\!\oint_{S_{1-5}} grad(\vec{u})\cdot\vec{n}dS = \sum_{m=1-5} grad(\vec{u})_m\cdot\vec{n}\delta S_m\\
&=[\Delta y(B_{i,j}grad(u)^x_{i+1/2,j} - B_{i-1,j}grad(u)^x_{i-1/2,j} - (B_{i,j}-B_{i-1,j})grad(u)^x_p)\\
&+\Delta x(A_{i,j}grad(u)^y_{i,j+1/2} - A_{i,j-1}grad(u)^y_{i,j-1/2} - (A_{i,j}-A_{i,j-1})grad(u)^y_p)]\vec{i}\\
&+[\Delta y(B_{i,j}grad(v)^x_{i+1/2,j} - B_{i-1,j}grad(v)^x_{i-1/2,j} - (B_{i,j}-B_{i-1,j})grad(v)^x_p)\\
&+\Delta x(A_{i,j}grad(v)^y_{i,j+1/2} - A_{i,j-1}grad(v)^y_{i,j-1/2} - (A_{i,j}-A_{i,j-1})grad(v)^y_p)]\vec{j}\end{aligned}\tag{10}$$

, wherein Δx is grid width in the x direction and Δy is grid width in the y direction, and vectors $\vec{i}$ and $\vec{j}$ correspond to unit vectors in the x and y directions, $\vec{n}$ corresponds to a unit vector normal to the differential surface S, and wherein $A_{i,j}$, $A_{i,j-1}$, $B_{i,j}$, and $B_{i-1,j}$ are fractions of area of grid, and wherein u designates velocity of flow in the x direction and v designates velocity of flow

in the y direction .

5. (Previously Presented) A method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 1, wherein when a no-slip boundary condition is used for a solid boundary, a first integral is performed on the solid boundary with the convection term being zero, a value of a middle point P of a cut line segment is used as an average for the pressure gradient term and the diffusion term, and a space integral is performed with areas fractions being applied to all of the terms.

6. (Previously Presented) A method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 1, wherein the boundary cell having the parameter smaller than a threshold value of VOF=0.01 is regarded as a complete solid,

for the boundary cell having the parameter larger than the threshold value, a definition point for the parameter calculated in a cut cell is set at a center of the boundary cell,

and a definition point for a parameter in a ridge is set at a center of a cell ridge, and a parameter at a middle point of a line segment is calculated by a linear interpolation.

7. (Currently Amended) A method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 1, wherein a drag force in a flow direction and a lift force in a direction vertical to the flow, acting on the object, are expressed by equations (12) and (13) that respectively express drag force and lift force as follows,

drag force:

$$F_x = F_D = \iint_V \left(\frac{\partial \sigma_{xx}}{\partial x} + \frac{\partial \sigma_{xy}}{\partial y}\right) dxdy$$

$$= \iint_V \left(\frac{\partial \sigma_{xx}}{\partial x}\right) dxdy + \iint_V \left(\frac{\partial \sigma_{xy}}{\partial y}\right) dydx = \oint_S \sigma_{xx} ds + \oint_S \sigma_{xy} ds \qquad (12)$$

$$= \int_{y_1}^{y_2} (\sigma_{xx}|_{f_1(y)} - \sigma_{xx}|_{f_2(y)}) dy + \int_{x_1}^{x_2} (\sigma_{xy}|_{g_1(x)} - \sigma_{xy}|_{g_2(x)}) dx \Big|_{only\ \ Cartesian}$$

lift force:

$$F_y = F_L = \iint_V \left(\frac{\partial \sigma_{yx}}{\partial x} + \frac{\partial \sigma_{yy}}{\partial y}\right) dxdy$$

$$= \iint_V \left(\frac{\partial \sigma_{yx}}{\partial x}\right) dxdy + \iint_V \left(\frac{\partial \sigma_{yy}}{\partial y}\right) dydx = \oint_S \sigma_{yx} ds + \oint_S \sigma_{yy} ds \qquad (13)$$

$$= \int_{y_1}^{y_2} (\sigma_{yx}|_{f_1(y)} - \sigma_{yx}|_{f_2(y)}) dy + \int_{x_1}^{x_2} (\sigma_{yy}|_{g_1(x)} - \sigma_{yy}|_{g_2(x)}) dx \Big|_{only\ \ Cartesian}$$

, wherein F_X designates drag force in the x direction and F_Y designates lift force in the y direction, and σ designates a stress tensor at the surface of the object..

8. (Previously Presented) A method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 1, wherein in fluid-structure interaction analysis accompanying a moving boundary, a fluid system and a structure system are separately analyzed for each predetermined time interval, and boundary conditions for the fluid system and the structure system are explicitly used.

9. (Currently Amended) A method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 8, wherein in analysis on a forcibly vibrated circular cylinder, the circular cylinder is set as a one-mass-point and a one-degree-of-freedom system such that the circular cylinder is a solid structure elastically supported and vibrating in a direction vertical to the flow,

and y-direction~~Y-direction~~ displacement of a center of the circular cylinder is given by equation (17), and a velocity boundary condition in the y-direction~~Y-direction~~ for a surface of the circular cylinder is given by equation (18),

$y = A\sin(2\pi f_C t)$ ...(17)

$v_W = A2\pi f_C\cos(2\pi f_C t)$ ...(18),

wherein A designates amplitude of y-direction displacement y, f_C designates frequency of forced vibration, and t designates time.

10. (Previously Presented) A method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 9, wherein movement velocity of the vibrating circular cylinder obtained by the equation (18) is changed to be given for each calculation time step for the velocity boundary condition on the flow field.

11. (Currently Amended) A method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 8, wherein in analysis on self-induced vibration due to a vortex shedding from the circular cylinder, a vibration equation having a dimension is expressed by equation (19) or equation (20), using a one-mass-point and a one-degree-of-freedom dumper/spring model,

$$m\frac{d^2\tilde{y}}{dt^2}+c\frac{d\tilde{y}}{dt}+k\tilde{y}=\frac{1}{2}\rho U_o^2 DC_L \qquad (19)$$

$$\frac{d^2y}{dt^2}+(4\pi hf_o)\frac{dy}{dt}+(2\pi f_o)^2 y=\frac{8h}{Sc}C_L \qquad (20)$$

,

wherein m designates mass of the circular cylinder, c designates a viscous damping coefficient, k designates an elastic recovery coefficient of the spring model, ρ designates fluid density, U_0 designates velocity of the uniform flow, D designates a diameter of the

circular cylinder, and C_L designates a lift force coefficient,

wherein f_0 designates a characteristic frequency, h designates a non-dimensional damping coefficient, Sc designates a Scruton number, and $y = A\sin(2\pi f_C t)$,

wherein A designates amplitude of y-direction displacement y, f_c designates frequency of forced vibration, and t designates time.

12. (Previously Presented) A method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 11, wherein the movement velocity of the vibrating circular cylinder calculated by equation (20) is changed to be given for each calculation time step for the velocity boundary condition on the flow field.

13. (Original) A method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 11, wherein initial displacement and initial velocity of the circular cylinder are set to be zero, the lift force is explicitly given by using a current value, and the vibration equation is integral by the Newmark's β method to obtain vibration displacement and vibration velocity of the circular cylinder.

14. (Currently Amended) A device for numerical analysis of a flow field of incompressible viscous fluid, directly using V-CAD data, the device comprising:

an input device for inputting external data including boundary data of an object that contacts incompressible viscous fluid;

an external storage device for storing substantial data of shape data and physical property data integrated into each other, and a storage operational program for the substantial data;

an internal storage device and a central processing device for executing the storage

operational program; and

an output device for outputting a result of execution of the storage operational program;

wherein the device for numerical analysis

(A) divides the external data into a plurality of cells having boundaries orthogonal to each other;

(B) classifies the divided cells into an internal cell positioned inside or outside the object and a boundary cell including the boundary data;

(C) determines cut points in ridges of the boundary cell on the basis of the boundary data;

(D) determines a polygon connecting the cut points to be cell internal data for the boundary face; and

(E) applies a cut cell finite volume method combined with a VOF method to a boundary of a flow field to analyze the flow field, wherein when the device for numerical analysis applies the cut cell finite volume method combined with a VOF method to the boundary of the flow field to analyze the flow field, the device for numerical analysis operates to

i. apply a two-dimensional QUICK interpolation scheme to a convection term for space integral;

ii. apply a central difference having precision of a degree of a second order to a diffusion term;

iii. combines the convection term and the diffusion term, and applies an Adams-Bashforth method having precision of a degree of a second order to the combined convection term and diffusion term for time marching; and

iv. applies a Euler implicit method having precision of a degree of a

first order to a pressure gradient term for time marching,

wherein for a two-dimensional boundary cell, a governing equation in the finite volume method is expressed by a governing equation (7),

$$\iint_{V_{i,j}} \frac{\partial \vec{u}}{\partial t} dV = -\iint_{V_{i,j}} div(\vec{u} \otimes \vec{u}) dV - \iint_{V_{i,j}} div(p\vec{I}) dV + \frac{1}{\mathrm{Re}} \iint_{V_{i,j}} div(grad(\vec{u})) dV \qquad (7)$$

,

wherein $-\iint_{V_{i,j}} div(\vec{u} \otimes \vec{u}) dV$ corresponds to the convection~~convention~~ term,

$-\iint_{V_{i,j}} div(p\vec{I}) dV$ corresponds to the pressure gradient term, and

$+\frac{1}{\mathrm{Re}} \iint_{V_{i,j}} div(grad(\vec{u})) dV$ corresponds to the diffusion term, wherein $\vec{u}$ designates velocity of flow of viscous fluid, V designates differential volume of the viscous fluid, $p\vec{I}$ designates pressure p of the viscous fluid along the $\vec{I}$ vector, and Re corresponds to a non-dimensional Reynolds number.

15. (Currently Amended) A computer readable medium comprising a program stored thereon for numerical analysis of a flow field of incompressible viscous fluid, directly using V-CAD data, wherein the program causes a computer to perform the steps of:

(A) dividing external data into a plurality of cells having boundaries orthogonal to each other, the external data including boundary data of an object that contacts incompressible viscous fluid;

(B) classifying the divided cells into an internal cell positioned inside or outside the object and a boundary cell including the boundary data;

(C) determining cut points in ridges of the boundary cell on the basis of the boundary data;

(D) determining a polygon connecting the cut points to be cell internal data for the boundary face; and

applying a cut cell finite volume method combined with a VOF method to a boundary of a flow field to analyze the flow field, wherein step (E) comprises the steps of

i. applying a two-dimensional QUICK interpolation scheme to a convection term for space integral;

ii. applying a central difference having precision of a degree of a second order to a diffusion term;

iii. combining the convection term and the diffusion term, and applying an Adams-Bashforth method having precision of a degree of a second order to the combined convection term and diffusion term for time marching; and

iv. applying a Euler implicit method having precision of a degree of a first order to a pressure gradient term for time marching,

wherein for a two-dimensional boundary cell, a governing equation in the finite volume method is expressed by a governing equation (7),

$$\iint_{V_{i,j}} \frac{\partial \vec{u}}{\partial t} dV = -\iint_{V_{i,j}} div(\vec{u} \otimes \vec{u}) dV - \iint_{V_{i,j}} div(p\vec{I}) dV + \frac{1}{\text{Re}} \iint_{V_{i,j}} div(grad(\vec{u})) dV \qquad (7)$$

,

wherein $-\iint_{V_{i,j}} div(\vec{u} \otimes \vec{u}) dV$ corresponds to the <u>convection</u>~~convention~~ term,

$-\iint_{V_{i,j}} div(p\vec{I}) dV$ corresponds to the pressure gradient term, and

$+\frac{1}{\text{Re}} \iint_{V_{i,j}} div(grad(\vec{u})) dV$ corresponds to the diffusion term<u>, wherein $\vec{u}$ designates velocity of flow of viscous fluid, V designates differential volume of the viscous fluid, $p\vec{I}$ designates</u>

pressure p of the viscous fluid along the $\vec{I}$ vector, and Re corresponds to a non-dimensional Reynolds number; and

(F) outputting to an output device a result of the method for numerical analysis of the flow field of incompressible viscous fluid, wherein the output device prints, or displays, or prints and displays, the result.